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National Space Test Centers Lewis Research Center Facilities

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NATIONAL SPACE TEST CENTERS

LEWIS RESEARCH CENTER FACILITIES

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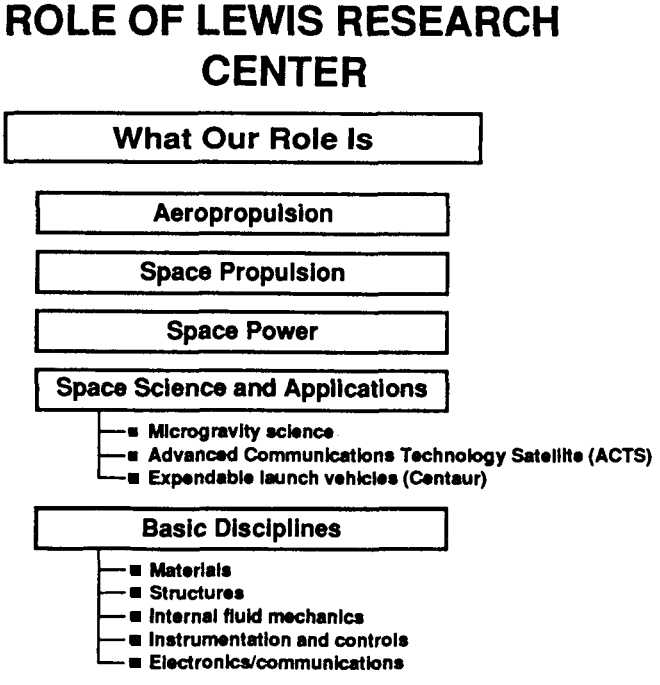
Abstract

The Lewis Research Center, NASA, presently has a number of test facilities that constitute a significant national space test resource. It is expected this capability will continue to find wide application in work involving this country's future in space. Testing from basic research to applied technology, to systems development, to ground support will be performed, supporting such activities as Space Station Freedom, the Space Exploration Initiative, Mission to Planet Earth, and many others.

The major space test facilities at both Cleveland and Lewis' Plum Brook Station are described. Primary emphasis is on space propulsion facilities; other facilities of importance in space power and microgravity are also included.

Introduction

The Lewis Research Center, a NASA field center, was originally created in 1941 as the Aeronautical Engine Research Lab, under NACA. The emphasis in those early days was primarily dedicated to the war effort and involved responsibility for improvement in aircraft engines and components, studying fuels and combustion and fundamental research in those areas of physics, chemistry, and metallurgy relevant to propulsion. This emphasis on propulsion has continued to the present day.



In 1958, the newly formed NASA absorbed the laboratory and it was renamed the Lewis Research Center. Lewis' emphasis, although still strongly dedicated to aeronautical propulsion R&T, was broadened to include space propulsion and space power R&T, and space science applications. The current role of the Lewis Research is summarized in the previous chart. Lewis' current role in space power includes lead center responsibility for the Space Station Freedom power system.

Over the course of the last 50 years, a broad based test facility capability has been built up at both the Cleveland site, located adjacent to Cleveland Hopkins Airport, and the Plum Brook Station, about 50 miles west of the Cleveland site, near Sandusky, Ohio. The Cleveland site encompasses about 350 acres, while Plum Brook Station encompasses over 5000 acres. The total plant present estimated replacement cost approaches $3 billion.

Between these two locations there are more than 500 specialized research installations of varying size and complexity. The major space test facilities that are part of the Lewis Research Center will be described in this paper.

Cleveland Site Facilities

Rocket Engine Test Facility

The Rocket Engine Test Facility is actually a complex comprising three test stands for testing chemical rocket engines and components. Test Stand "A" is designed for sea level testing of vertically-mounted rocket engines discharging into an exhaust gas scrubber and muffler. A wide variety of propellant combinations can be handled with chamber pressures over 4000 psi and thrust levels up to 50 000 lb.

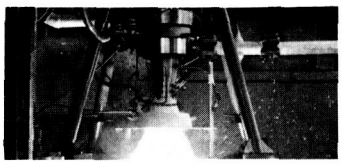
Test Stand "B" is designed for altitude testing of rocket engines exhausting into a diffuser, cooler, and two stage ejector system. The "B" stand can test H-O engines with chamber pressures up to 3000 psi, thrust levels to 4000 lb, and high area ratio nozzles up to 1000 to 1 at simulated altitudes up to 130 000 ft.

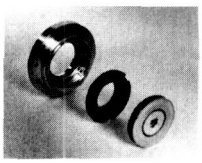
Test Stand "C", the most recent addition, is designed for testing of rocket engine turbopumps and turbopump components. Liquid hydrogen and liquid oxygen turbopumps can be tested with ambient temperature turbine drive. Current testing involves liquid oxygen shaft seals experiments.

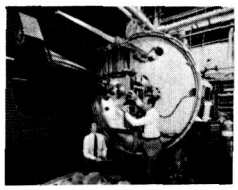
Recent work at the Rocket Engine Test Facility has focused on technology for future rocket engines, either for earth to orbit applications or for space applications, especially with liquid hydrogen and liquid oxygen propellants.

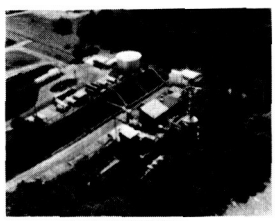
*Chief, Aerospace Engineering Branch.

ROCKET ENGINE TEST FACILITY









CAPABILITIES

- MULTI-PROPELLANT: LH_2, LO_2, N_2H_4, RP1
- SEA LEVEL ROCKET TEST-TO 50 000 lbf THRUST
- ALTITUDE ROCKET TEST-TO 1500 lbf THRUST
- CHAMBER PRESSURE-TO 4000 PSIA
- ROCKET LIFE TESTING-200 TESTS PER DAY
- ROCKET TURBOPUMPS-TO 15 000 lbf THRUST SIZE
- TURBOPUMP COMPONENTS-TO SSME SIZE

PROGRAMS

- PROPULSION BASIC RESEARCH & TECHNOLOGY
  - COMBUSTION STABILITY
  - ADVANCED COOLING CONCEPTS
  - THRUST CHAMBER LIFE
  - LOX COOLING
  - METALIZED PROPELLANTS
- CHEMICAL TRANSFER PROPULSION
  - NOZZLE PERFORMANCE & HEAT TRANSFER
  - THRUST CHAMBER PERFORMANCE & LIFE
  - TURBOPUMP SEAL PERFORMANCE & LIFE
  - ADVANCE BEARING TECHNOLOGY
  - PUMP PERFORMANCE
  - DIAGNOSTICS

Electric Power Laboratory

The main feature of the Electric Power Lab (EPL) is two large space simulation chambers which are designated as Tank 5 and Tank 6. Tank 5 is 63 ft long and 15 ft in diameter, while Tank 6 is 70 ft long and 25 ft in diameter. Both chambers are provided with extensive vacuum pumping trains consisting of diffusion pumps, blowers, and mechanical backing pumps which allow vacuums in the 10^{-6} torr range and also the high pumping speed required by various electric propulsion devices. In addition, a helium cryopanel has recently been added to Tank 5 which, when employed, provides more than a 10 fold increase in pumping speed.

EPL COMPLEX CAPABILITIES

LARGE SPACE SIMULATION CHAMBERS

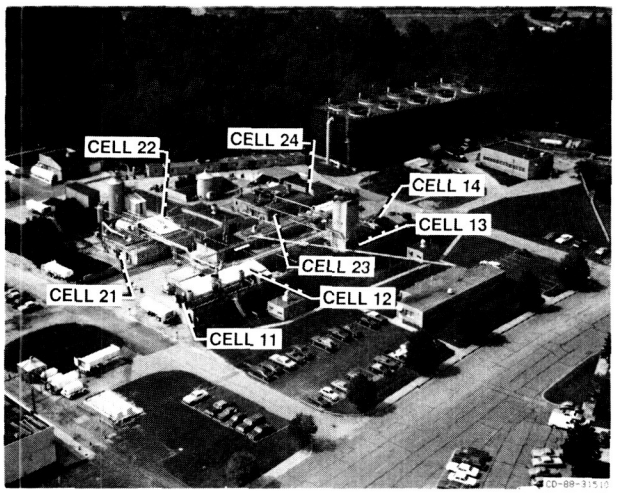
Both chambers are extensively used to support programs in electric propulsion such as ion thrusters, arcjets, and resistojets. The capability is also used to test space power systems and components and evaluate plasma interaction effects. It is worthy to note that a 1.2 kW arcjet thruster was successfully operated in this facility for 500 cycles and more than 1000 hr. As a result, an arcjet system will be used in space for the first time in 1993 for the AT&T Telstar IV satellite. This represents the first time industry has accepted electric propulsion for operational applications.

Rocket Laboratory Group

The Rocket Laboratory Group (RL) is a complex of nominally 10 relatively small test cells that were originally constructed in the early 1950's. Much of the first rocket engine testing at Lewis was done in this area including work with such exotic propellants as hydrogen-fluorine. In the last 5 years or so, this area has been undergoing a revitalization in terms of increased utilization of these test cells and new facility construction for rocket engine technology. The smaller scale employed, compared to some of the larger facilities, allows reduced turn-around time and hardware expenditures.

Presently, extensive work is being conducted in high temperature thermal shock testing of materials. Recognizing a high potential growth area in

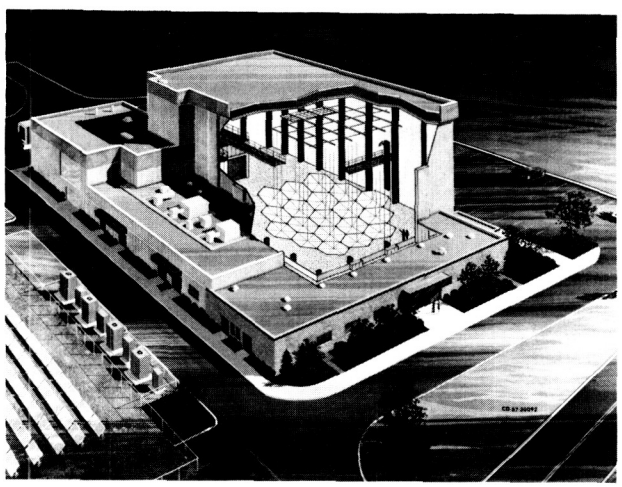
ROCKET LABORATORY GROUP



low thrust propulsion (5 to 1000 lb thrust class), a new test cell was recently built and is now doing work with H-O propellants. Research is also being conducted with metallized propellants, catalytic, and multicompartment ignition. A new test cell, planned for 1991, will be equipped with the latest laser diagnostic equipment to examine combustion fundamentals.

Power Systems Facility

POWER SYSTEMS FACILITY

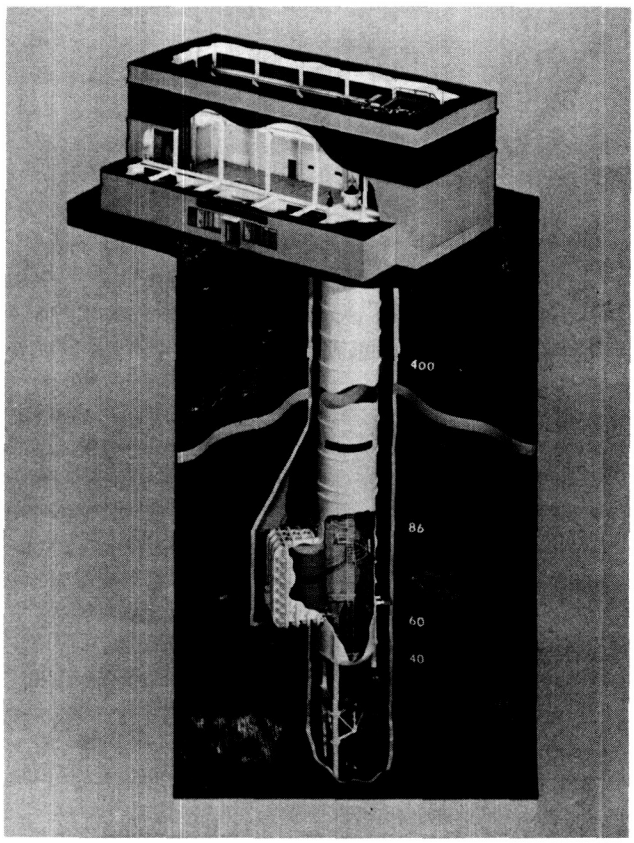


The Power Systems Facility, Lewis' newest facility, was constructed in 1988. It was designed for testing and validating Freedom's electric power system components and its control systems. Some of the features include an 8000 ft^2 high bay room which can function as a class 100 000 work area. An outdoor solar array field adjacent to the facility, capable of generating 30 kW of power, supports electric power system tests. The facility will accommodate an engineering support center to support the Freedom power system while Freedom is in orbit.

Testing is currently proposed in three hardware development areas: nickel-hydrogen batteries, solar concentrator panels and mirrors, and the power management and distribution system and its components. The facility is equipped to test growth versions of Freedom which will rely on solar dynamic technology. A critical element of the solar dynamic power module is the solar concentrator mirror which is shown in the illustration.

Zero Gravity Facility

ZERO GRAVITY FACILITY



The Zero Gravity Facility, sometimes called Zero G, is designed to study the behavior of aerospace components, liquids, gases, and combustion under zero gravity and low flow environments. The steel chamber is 20 ft in diameter and 470 ft deep. Before a test, the pressure inside the chamber is reduced to 0.01 torr to lower the air drag on the falling vehicle below the 10^{-5} g level. Experiment packages weighing up to 3000 lb can be recovered without damage. The facility can accommodate test articles up to 5 ft in diameter and 15 ft in length. High speed motion picture cameras and a telemetry system are used for data acquisition.

The facility can be operated in 2 modes. In the simple drop mode, 0g condictions are maintained for 5 sec. A second mode consists of propelling the test article upward from the bottom to the top and then letting it fall back down. This mode results in about 10 sec of the weightless environment.

Plum Brook Station Facilities

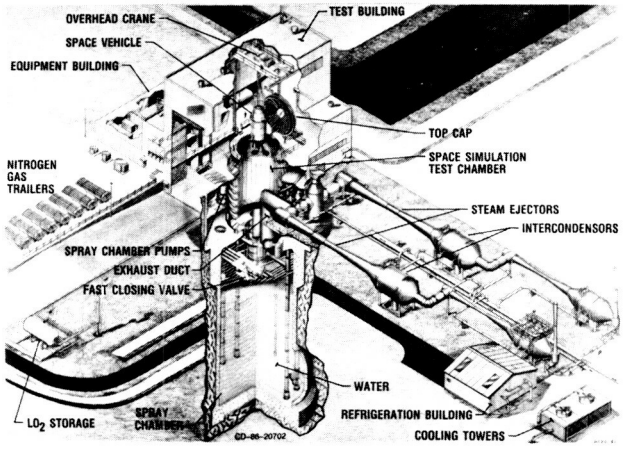
The Plum Brook Station was originally the Plum Brook Ordnance Works, which was used during WW II for the manufacture of TNT. The area was acquired by Lewis in the mid 50's and for almost 20 years was the site of the construction and operation of a series of about 16 test facilities primarily dedicated to chemical propulsion.

A cutback within NASA during the early 70's resulted in most of the facilities being placed on standby status in 1974. At that time, it was decided that at least four of the facilities would receive special preservation and standby maintenance to allow their reactivation, if needed, in no longer than 1 year. In the last few years, a number of these facilities have been placed back in service. In as much as Plum Brook Station is presently staffed by a skeletal civil service force, the facilities are basically contractor operated.

The Plum Brook facilities of interest in space testing are described below:

Spacecraft Propulsion Research Facility (B-2 Site)

SPACECRAFT PROPULSION RESEARCH FACILITY (B-2 SITE)



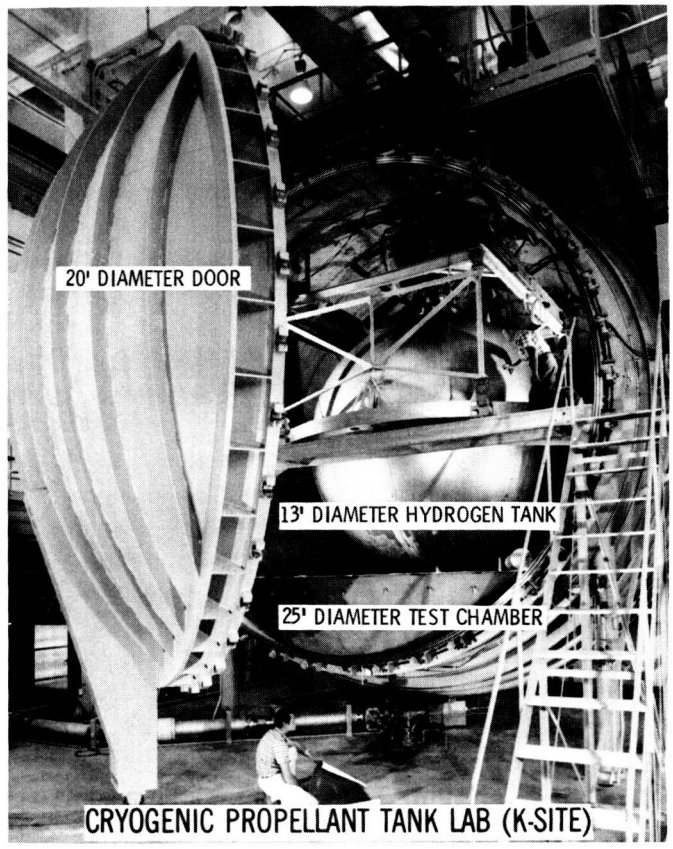
The Spacecratt Propulsion Research Facility was designed to conduct research, development, and validation tests on a variety of spacecraft and their propulsion systems. The facility provides space simulation using lamps for solar simulation, LN_2 cooled cryowalls, and a high vacuum pumping system. The facility will accommodate spacecraft and rocket vehicles up to 22 ft in diameter and 50 ft high. The facility is also equipped with a 3 stage steam ejector system which provides for hot firing LO_2, LH_2 engines for more than 5 min.

The test vehicle is mounted in a vertical position in the test chamber and, after the desired space soak period, fires its rocket engines downward through an exhaust diffuser into a water spray chamber. A valve in the bottom of the diffuser seals the test chamber from the spray chamber during the cold soak period. This valve can be opened in less than 0.5 sec immediately prior to engine firing. During firing, cooling water is pumped directly from the sump through the spray bars at a rate of about 200 000 gal/min to quench the exhaust gases.

This facility successfully test fired a complete Centaur stage shortly after construction. There are future plans to use the facility for Advanced Expander Test Bed (AETB) engine tests in about 1994.

Cryogenic Propellant Tank Research Facility (K-Site)

CRYOGENIC PROPELLANT TANK RESEARCH FACILITY (K-SITE)



This facility is designed for performance testing of a wide variety of rocket propellant tank systems. These include cryogenic fluid slosh tests, tank-fill and expulsion tests, and thermal performance of insulation systems. Boundary conditions, from ground hold to deep space, can be controlled utilizing a heated or cooled cryoshroud enclosing the complete test package in a vacuum chamber. The test chamber is a 25-ft diameter steel sphere.

Most recently, this facility has been reactivated for slush hydrogen technology development testing and to support the COLDSAT (Cryogenic On-Orbit Liquid Depot-Storage, Acquisition, and Transfer) flight experiment.

Space Power Facility (SPF)

SPACE POWER FACILITY (SPF)

The Space Power Facility (SPF) is the largest nuclear-rated, controlled environmental test chamber in the world. The chamber is 100 ft in diameter by 122 ft high, enclosing about 800 000 ft^3 of unobstructed volume.

The facility was designed to test space nuclear and nonnuclear power generation or propulsion systems up to 15 mW thermal power. The facility can also be used to perform qualification tests for space bound hardware including spacecraft certification and space station component certification. The facility can fully simulate space vacuum.

The basic facility consists of an aluminum test chamber surrounded by a heavy concrete enclosure for nuclear shielding and containment. To date, no nuclear experiments have been run at the facility. The facility was used for a number of years by a DOE contractor for classified projects, was recently refurbished, and is presently available for utilization by NASA or its contractors.

Summary

Lewis Research Center's major space test facilities have been described. These facilities, along with many other space research installations at the Center, qualify Lewis as a significant national space test center. This extensive space test capability promises to play an important role in many of the nation's future space endeavors.

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